Green Revolution: a name that still baffles many

By

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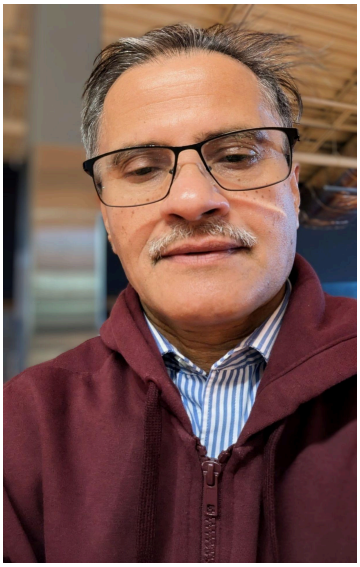
About the author



Indrajit Roy is an agricultural scientist with expertise in rural development and socio-economic empowerment. He was born in Mohanganj, Netrokona district, in 1956. He completed his secondary education from Mohanganj Pilot High School in 1972 and his higher secondary education from Government Anandamohan College, Mymensingh in 1974. In 1976, he went to the then Soviet Union for higher education on a scholarship provided by the Soviet government. He studied at the Kuban State Agrarian University in Krasnodar, now the Russian Federation. He received a Master's degree in Agricultural Science in 1982 and a Ph D in Plant Breeding and Seed Production in 1986. After returning home in 1986, he joined the Bangladesh Agricultural Research Council and worked there as the Chief Scientific Officer until March 2001. He received training on project analysis from the United States Department of Agriculture in 1992. In 1999, he did post-doctoral research at the Department of Plant Breeding at Kyushu University in Fukuoka, Japan. He has been living permanently in Toronto, Canada since 2001. He is working as an international consultant on agricultural research and rural development at various international organizations, including the Food and Agriculture Organization of the United Nations. In his personal life, he is married and has two sons.

Background

Green Revolution in its standard international version stands for the transformative changes that agriculture in most countries of Asia and Latin America had gone through in the later half of the twentieth century. But the scientific foundation that gave start to this revolution was developed beginning in the early 1900s. However, the timeframe spanning from the early 1960s to the late 1990s is generally agreed upon to be named as the Green Revolution. Because it was the period when most consequential activities driving the revolution happened. When an event is called revolution, it means it happened at a relatively fast pace, profoundly altering existing systems and structures. All revolutions have certain kinds of ambitions and lofty goals. So, they can't happen all of a sudden. They require years of concerted efforts and engagement of many actors at different levels to navigate the change process toward the desired goal. That goal in almost all cases has some kind of ideological content. It may not always be explicitly formulated. Often it is embedded within seemingly neutral strategic goals.

The Green Revolution was such a revolution. Its stated strategic goal was to combat global hunger and poverty by helping poor developing countries rapidly increase their domestic food production. But it also had an ideological content which was more important and urgent than the stated goal. It was to counter the spreading of communist ideology and the influence of the Soviet Union in the poor developing world. There was a fear in the US Government circles that hunger and poverty could lead to communist uprisings in these countries. The architect and chief financier of the Green Revolution was the US Government but it didn't always act directly. Initially it channeled resources through the Rockefeller Foundation, the Ford Foundation and the World Bank. Later in 1961, a government agency – the United States Agency for International Development (USAID) - was established for this purpose.

About 50 percent of USAID's budget in that period was earmarked to support the groundwork to start the Green Revolution. It was done by funding the research, infrastructure building, facilitating international collaboration, and shaping local buy-ins. The latter was done by persuading influential decision makers and agricultural scientific leaders to abandon the ongoing research approach and embrace the principles of the Green Revolution. To do this, certain activities required specific skills in advancing both philanthropic and foreign policy goals. The USAID came handy for this purpose. The term "Green Revolution" was coined by William S. Gaud, the administrator of the USAID, in a 1968 speech. He explicitly distinguished this "revolution" of agricultural technology from a "violent Red Revolution."

The idea that drove the revolution

The idea that was behind the Green Revolution wasn't entirely new. It was the Western industrial agricultural model that took shape in the early 1940s. It was based on intensive cultivation of high-yielding disease resistant crop varieties, developed through scientific breeding programmes, and application of high amounts of chemical fertilizers, pesticides, and irrigation water. To be true, "revolution" isn't the best word to say how things change in agriculture and the natural environment.

What happens there is a process of slow change, which is evolution. The “revolutionary” thing in the Green Revolution oriented to the developing world was to adapt the industrial agricultural model to the specific context of smallholder peasant farming. It was also about pushing through the corridors of power and public opinion the idea that it was the only way forward for food-deficit countries to rapidly increase food production and ensure their food security.

The leader behind the revolution

To be successful, all revolutions require a leader who has both wisdom and courage to conceptualize the new idea and put forward a plan about how to do it. That kind of leadership for the Green Revolution came from Dr. Norman E. Borlaug, an American agronomist and plant pathologist. The story begins in 1942 when Mexican officials asked the Rockefeller Foundation for aid when the outbreak of rust, a major fungal disease, devastated wheat crops and greatly reduced harvests for three years in a row. The Foundation financed a group of scientists who began a research programme in Mexico to breed wheat resistant to diseases and drought. One of these scientists, Norman Borlaug (1914–2009), set up an experimental station in Ciudad, Obregon, in northwest Mexico. In the 1950s, he brought into his breeding programme the partly Japanese dwarf wheat variety Norin 10.

By the early 1960s, Borlaug’s group had bred semi-dwarf high yielding varieties (HYV) that produced much higher yields when used with a package of fertilizers, pesticides, and irrigation. These varieties inherited from the Japanese variety one or more “reduced height genes” (Rht) which caused the plants to grow short but very thick and sturdy straw that would be much less likely to “lodge” or collapse. This crucial phenotype transformed these plants into HYV because it allowed farmers to use more fertilizer so that the plants could develop a larger spike containing more and heavier spikelets without the risk that lodging would destroy the crops. In 1963 the Ciudad Obregon Centre was renamed the International Center for Improvement of Maize and Wheat, known by its Spanish acronym, CIMMYT. Dr. Borlaug also had leadership skills to work through the corridors of power to convince world leaders to adopt his HYVs. In 1965, Dr. Borlaug persuaded the Indian Government to import HYVs – Lerma Rojo 64, Sonora 64, Siette Serros, Pitic 62 – on a large scale for commercial cultivation. These varieties dramatically boosted wheat production, with yields increasing by over 50 percent in many regions by 1970. For this success as well as his previous work, Borlaug was awarded the Nobel Peace Prize in 1970.

How did the revolution roll out?

The International Rice Research Institute (IRRI) was established in 1960 at Los Baños, Philippines. While IRRI was established as a brand new institution, CIMMYT had an existing institutional basis. Dr. Norman Borlaug became the first Director General of CIMMYT who served from 1966 to 1979. An American scientist, agronomist and plant physiologist, Robert F. Chandler Jr was appointed as the first Director General of the International Rice Research Institute (IRRI) who served from 1960 to 1972. The first HYV of rice to roll out from IRRI was IR8 released in 1966. It was developed by crossing “Peta” – a tall Indonesian rice variety with vigorous vegetative growth - with Dee-geo-woo-gen (a short-statured

Taiwanese variety). Called Miracle Rice, IR8 produced significantly higher yields than did the traditional varieties.

The release of IR8 marked a pivotal moment in the Green Revolution. While acclaiming HYVs for their high yield potential, many often missed the point that there was also a significant cost to the farmers to grow them. These varieties produced high yields only when farmers applied adequate chemical fertilizers and pesticides to control pest infestation. For growing HYV of rice there was also a need for sufficient irrigation water to keep rice fields flooded for the entire growing season. Despite their shortcomings, these HYVs opened the door to transfer the trait of high yielding ability to locally adapted cultivars through further breeding work. In short, the key assumption of the planners of the Green Revolution that the HYVs could rapidly increase production of staple foods in developing countries was validated.

Mexico became the choice for founding of CIMMYT by default because of ongoing wheat breeding work supported by the Rockefeller Foundation. But the choice of the Philippines for founding of IRRI was mainly driven by the consideration to use it as a deterrent to peasant-led communist uprisings fuelled by poverty and hunger in South-east and South Asia. The Philippines was an US ally and its government led by President Carlos P. Garcia (1957-1961) and Diosdado Macapagal (1961–1965), the period IRRI was founded and its operations began, were staunchly anti-communists. Both viewed IRRI not only as an institution to solve the food crisis and combat poverty but also as a bulwark against infiltration of communist ideas from both the Soviet Union and China.

But the biggest prize for the US was getting India on board with the Green Revolution despite the country not being an US ally. The country was officially neutral in the Cold War as a leader of the Non-Aligbed movement, a grouping of newly independent developing nations in Asia, Africa, and Latin America, with a soft tilting toward the Soviet Union-led socialist block of nations. Although the Philippines hosted IRRI, it was India which became the centre of gravity of the Green Revolution in Asia. We will discuss separately how a country like India with its 35-year old indigenous agricultural research programme was persuaded to break with the past and embrace the Green Revolution.

How did the revolution spread

All revolutions build on successes. And so did the Green Revolution. To expand the scope of the revolution beyond the staple crops and spread it throughout the world, a new organization called the Consultative Group on International Agricultural Research (CGIAR) was established in 1971. The World Bank, under its president Robert S. McNamara, a former US defence secretary, took the lead in its establishment. The US Government conceived CGIAR as a consortium of donors – governments, foundations and private sector organizations – to provide stable funding to scale up the Green Revolution and maintain its momentum. The US Government through the USAID became a major funder along with other donor countries like Canada, Germany, and the UK. This structure allowed pooling of resources and its management by a collective group still allowing the US Government to retain its influence on key policy making decisions.

By 1990, the number of CGIAR institutions rose to eighteen to cover non-crop agriculture – livestock, fisheries, forestry, water management, as well as policy and organizational issues of the Green Revolution. CGIAR provided adequate funding to relevant research, technology demonstration and dissemination, training for scientists and government officials, international exchanges, networking and collaboration. It also had a well-funded buy-in programme. It operated by offering scholarships toward academic degrees, short-term training, study visits, consultancies for university professors and retired government officials. Its goal was to convert skeptics of the Green Revolution into its supporters. With such a comprehensive approach, the CGIAR became the engine to drive the Green Revolution not only in farmers' fields but also across the elite societies to maintain the focus of the Green Revolution on its being a counterweight to red revolutions.

All revolutions pass through transitions. They typically begin with dramatic unfolding of the change-promising new story. As momentum builds lifted by enthusiasm, initial gains accumulate rapidly helping to reach the peak point and then level off after a certain period. When the creative force unleashed by the new story fizzles out, a decline looms and the things no longer look like a revolution. The Green Revolution too passed through a similar transition. Its heyday was the mid-1960s – mid 1980s. During this period grain production in many developing countries increased rapidly due mainly to higher genetic yield potential of HYVs in combination with application of chemical fertilizers, pesticides, and irrigation water.

It was the early successes of the Green Revolution that mattered most to the ideologues of the Green Revolution. Countries like India, Pakistan, Bangladesh and many others which were dependent on food imports and food aid succeeded in significantly increasing their domestic food production. Some of them became self-sufficient in food, while others attained near food self sufficiency. For the policy makers attaining this status was a high water mark because it validated their bet on the Green Revolution as the correct strategy for agricultural development. It also accelerated indigenization and ownership of the Green Revolution by national governments.

Green Revolution's declining phase

From the viewpoint of the Cold war ideologues , the immediate threat of persistent food shortages and famines receded. It eased their concerns about peasant uprisings and, in general, pivoting of national politics toward the radical left in the foreseeable future. The investments that the US-led Western alliance made in the Green Revolution to use it as a tool to contain the influence of the Soviet Union in the developing world produced handsome returns. By the mid-1985s, annual growth rates of yields of HYV rice and wheat started decreasing, eventually reaching a plateau in the early 1990s. It meant the relative contribution of genetic yield potential in total annual grain production was declining. The emphasis was shifting on non-genetic factors to maintain an upward trend in food production.

These non-genetic factors were purchased inputs – chemical fertilizers, pesticides, and energy, electricity and diesel fuel to run pumps for lifting water for irrigation. The reasons for plateauing of the HYV yields are well known and documented in hundreds of studies. All trace their origin to widespread negative

impacts the Green Revolution produced across the natural environment, public health and the food chain. These were loss of inherent soil fertility, soil degradation, contamination of soils and the aquatic ecosystems by heavy metal residues from synthetic fertilizers and pesticide, loss of crop diversity in farmers' fields due to intensive monoculture of staple cereals, loss of plant biodiversity, entry of toxic residues from chemical inputs in the human food chain and a host of other impacts.

When in the light of these shortcomings , the Green Revolution was coming under increased scrutiny and criticism worldwide, an epoch-making momentous event occurred that was the coveted goal of the Green Revolution. The Soviet Union disintegrated in 1991. It was hailed in the West as the "end of history". As the epoch of the Red Revolution came to an end, there was no rationale for the Green Revolution to continue. It was also declared over having achieved its ultimate goal. But that didn't mean it died. The Green Revolution is still there. It simply can't die because the changes that it brought about in the farming practices of smallholder-dominated agriculture over more than three decades are so extensive and deep that it can't be rolled back in the same way as it was launched. Other names are used to shed the baggage associated with the word "Revolution" in a system, which is dominated not by the proletariat but by the bourgeoisie.

In the early 1990s, the Food and Agriculture Organization of the United Nations (FAO) came forward with one of the most suitable alternative names – sustainable intensification, sustainable agriculture. It was later absorbed in the UN's Sustainable Development Goals (SDGs). There are also other names in use, such as Evergreen Revolution, Precision Agriculture, Nature-friendly Agriculture, etc. But these names just provide a cover for the ongoing Green Revolution. The simple way to test this assumption is to look at the trend of the use of chemical fertilizers, pesticides and irrigation water by the farmers. There is no sign of scaling back the use of these inputs. The new generation of the HYVs are also being developed on the genetic basis of older HYVs but with expanding use of modern biotechnology.

The only difference is that the Green Revolution now is wholly nationally owned and managed by the national agricultural research and extension systems without much patronage by the West. It is evident from a notable decline in the US government funding for the CGIAR institutions. As stated above, for the US, the sense of urgency and the strategic imperative that had previously driven the Green Revolution faded. It was reflected in reduction of unrestricted core funding that allowed the CGIAR institutions to set their own research priorities and support long-term, fundamental and strategic research that was the driving force of the Green Revolution. In place of unrestricted core funding, donor preference shifted to bilateral "earmarked" funding for specific projects and programmes that forced the CGIAR to switch to a survival mode including enhanced collaboration with the private sector. To cope with the reduced flow of core funding, the CGIAR embarked on restructuring of its management and streamlining governance structure to reduce duplication of functions and other cost-cutting measures. Beginning in 2018, the reforms took shape in 2023 in a different organizational model known as "One CGIAR".

India Story

The case for the Green Revolution in India and elsewhere in Asia was made on the assumption that population is increasing at a Malthusian growth rate that can outstrip food supply leading to widespread hunger unless local food production isn't dramatically increased within a short period. The Malthusian theory in its core was flawed because it took a simplistic view of how population grows and how peasants conduct their farming practices to grow food. After independence from the British in 1947, food insecurity and malnutrition was widespread in India. But the country didn't experience massive food shortages causing famines with large-scale starvation deaths.

In the early 1960s, India's total annual demand for wheat was estimated in the range of 14–16 million tonnes. But domestic grain production wasn't enough to meet the demand which necessitated imports to close the gap. India imported 3.747 million tonnes of grain in 1960–61, 5.14 million tonnes in 1961–62, 4.56 million tonnes in 1963–64, 10.5 million tonnes in 1965–66. The sudden surge of import in 1965–66 was due to two successive crop failures in 1963–64 and 1964–65. But the state of food insecurity that India was facing then was far from being dire. The country could still wait for a few more years until more improved crop varieties developed by the Indian agricultural research system were available for cultivation. And that was a real possibility. If we follow the timeline of Dr. Norman Borlaug and his Team's wheat breeding work under the Mexican Agriculture Program (MAP), it took 16 to 18 years to develop the HYVs of wheat that became the vehicle for spreading the Green Revolution. By that measure, India's own high yielding disease resistant varieties of wheat developed through IARI's ongoing wheat breeding programme could appear in farmers'fields by the early 1970s.

But the US policy makers became adamant to push the Green Revolution model through the Indian Agricultural Research System. For this purpose, they used their full spectrum of political and diplomatic leverages including sizable food assistance the US Government provided through the PL-480 programme. The scientific-technical connections built with Indian Agricultural scientists were also put into use. It was in September 1953 that Dr. Norman Borlaug, then leading the Mexican Agricultural Programme first met Dr. M.S. Swaminathan, the future father of India's Green Revolution, at the University of Wisconsin-Madison during the convention of the American Institute of Biological Sciences. At that time, Dr. Swaminathan worked as a scientist at the Indian Agricultural Research Institute (IARI). During this period, he conducted research in genetics and plant breeding, focusing on potato and rice. During 1954–1965, he served as the Head of the Division of Botany at IARI. In this role, he led research efforts in crop improvement, particularly in wheat and rice. In the years following, Dr. Borlaug cultivated this relationship through technical collaboration and scientific exchanges.

The period 1960–1965 was marked by quick succession of independent India's political leadership. The first prime minister, Jawaharlal Nehru ruled over 1947–1964 followed by Lal Bahadur Shastri (1964–1965) and Indira Gandhi (1966-onwards). During such a transition of political leadership, bureaucrats exercised formidable power in crucial decision making. One such bureaucrat was B. Sivaraman, a British-schooled Indian Civil Service officer (ICS), the elite civil service of the British Empire in India. He was the Secretary of the Ministry of Food and Agriculture from 1964 to 1966 and later

became Cabinet Secretary of India (1969–1970). It wasn't difficult for the US diplomats in India to work with him to push the agenda of the Green Revolution to the political level. B. Sivaraman indeed played a significant role in convincing then Agriculture Minister C. Subramaniam on the merits of introducing Mexican HYVs in India. Agriculture minister Subramaniam became a key advocate of the Green Revolution, seeing in it a prospect for overcoming perennial food shortages and attaining food self-sufficiency relatively quickly. He approved importing 18,000 tonnes of Mexican wheat seeds in 1966 for farm-level cultivation in India, which marked the beginning of the Green Revolution In India.

However, getting the Indian Agricultural scientists fully on board with the model of Green Revolution proved trickier. Because Dr. Swaminathan, with whom Dr. Norman Borlaug closely collaborated, wasn't the top scientist in India's agricultural research system. It was Dr. B.P. Pal, the celebrated scientist, a noted wheat breeder, who developed the NP series of improved varieties of wheat with resistance to all three types of rust diseases and high yielding ability. These varieties played a crucial role in preventing crop losses and increasing production of wheat in India during 1940–1960 and laid the foundation of India's wheat breeding research to take on the new challenges. He was the first Indian Director of the Indian Agricultural Research Institute (IARI) who served from 1950 to 1965.

Dr. Pal was also known to support the introduction of Mexican HYVs of wheat developed by Borlaug in India, but he had concerns about the long-term impacts of this approach. As a plant breeder, he foresaw potential loss of traditional varieties due to widespread adoption of a few HYVs, overreliance on chemical fertilizers and pesticides with potential negative environmental consequences. He was particularly concerned about long-term sustainability of the new approach. When the Government of India gave permission to import Mexican varieties of wheat on a large scale for commercial cultivation which saw the beginning of the Green Revolution in India, Dr. B.P. Pal was transferred to the Indian Council of Agricultural Research (ICAR), as its first Indian Director General.

In this role Dr. Pal served from August 1950 to July 1965. It was largely an administrative role to oversee the entire agricultural research system including the IARI but with less involvement in hands-on wheat breeding research. Dr. M.S. Swaminathan became the Director of the Indian Agricultural Research Institute (IARI) from July 1966 to 1972. It was unknown whether this change was made to give Dr. Swaminathan a freer hand in reorganizing IARI's wheat breeding programme centered on the Green Revolution and close collaboration with Dr. Norman Borlaug. Dr. Pal's work was quietly abandoned although it was maintained that Dr. B.P. Pal's varieties laid the foundation of the Green Revolution in India. Dr. M.S. Swaminathan became the face of India's agricultural research in the new era widely regarded as "the father of India's Green Revolution".
But there is a different side to this story when it is viewed from farmers' perspectives. It seldom emerges in the mainstream. An excerpt from an open letter in which farmer Bhaskar Save wrote to M S Swaminathan in 2006. He was scathing about the impact of the Green Revolution and Swaminathan's role in it:
"You, M S Swaminathan, are considered the 'father' of India's so-called 'Green Revolution' that flung open the floodgates of toxic 'agro' chemicals – ravaging the lands and lives of many millions of Indian farmers over the past 50 years. More than any other individual in our long history, it is you I hold

responsible for the tragic condition of our soils and our debt-burdened farmers, driven to suicide in increasing numbers every year." (https://janataweekly.org/myths-about-the-green-revolution-3-articles/)

The Green Revolution: when exactly did it begin?

Let's take a broader view of the Green Revolution for what it was in historical context. It was about scientific efforts of many scientists across many countries to combat famines, frequent crop failures and dependence on imported food. It was pursued through development of disease-resistant high yielding varieties of staple crops. Judging by that yardstick, the Green Revolution began much earlier than the one commonly associated with the name of American plant scientist, Dr Norman Borlaug that occurred over 1960–1990. The wheat breeding materials that became available to Dr. Borlaug, when he started his experimental station in Mexico in the early 1940s embodied the contribution of scientists from Japan, Russia, Italy, Argentina, Mexico and several other countries.

The short wheat varieties that Japanese farmers obtained in the sixteenth century were from Korea, where they had been grown since late antiquity. In the 1920s, Japanese breeders crossed a short variety with varieties from the Mediterranean and Russia from which they selected the variety Norin-10 with a plant height of 45.7 centimeters. Meanwhile the first European to incorporate in his breeding programme Japanese varieties and breed what were, in essence, first HYVs was the Italian scientist Nazareno Strampelli (1866–1942). Strampelli and his co-workers at his research centre in Ricti produced at least 65 new varieties of wheat that substantially increased wheat production in Italy between 1900 and World War II. He specifically aimed to breed wheat with a shorter stem to prevent lodging, early maturity and rust resistance using the Japanese wheat variety Akakomugi.

Through these crossings, two varieties – Ardito and Mentana – were developed and released in 1920. These varieties were grown on millions of hectares of land in Italy and elsewhere. To spread his varieties beyond Italy, Strampelli visited Argentina in 1923 with some of his varieties and encouraged local

scientists to use his varieties in their breeding programmes. One breeder used Ardito and Mentana in his crossings from which he developed varieties Klein 30, 31 and so forth. Norman E. Borlaug used Mentana as one of his main breeding varieties in Mexico in the 1940s and applied the same basic approaches as Strampelli. The work of Strampelli and other Italian breeders, as an Italian scholar put it, was the first example of the "Green Revolution." As we see from these breeding works, the key approach in all cases was the same - use in breeding programmes diverse wheat germplasm domestic as well as foreign to create new plant types with short sturdy stems to prevent lodging and resistance to rust and other diseases to produce much higher yields.

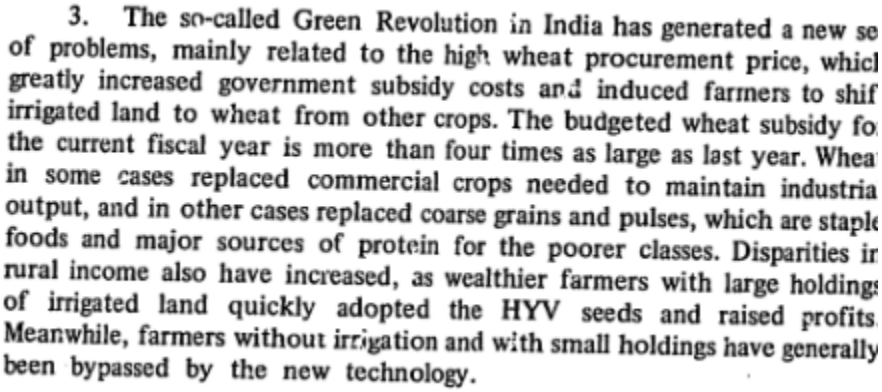
In India, as discussed above, Dr. B.P. Pal developed the New Pusa (NP) series of wheat varieties at the Indian Agricultural Research Institute (IARI) in the 1930s to 1950s, focusing on rust resistance (leaf, stem, and stripe rusts). He used a systematic hybridization breeding approach, incorporating genetic materials from both indigenous Indian varieties and exotic introductions from Australia, Italy, and the US to transfer resistance genes into adapted backgrounds. This involved crossing susceptible local wheats with resistant exotic lines, followed by selection and backcrossing over multiple generations to combine yield, adaptability, and disease resistance.
Key genetic materials included: *Indigenous stocks*: Local Indian wheat varieties, such as those from the earlier Pusa series (e.g., Pusa 4, Pusa 6, Pusa 12), which provided adaptation to Indian conditions but were susceptible to rusts; *Australian varieties*: Bena, Ridley, and Federation, valued for their rust resistance and used as donors for brown and yellow rust tolerance in early NP lines like NP783–NP786; *Italian varietie***s**: Padova I and II, which contributed stem rust (black rust) resistance genes, incorporated into varieties like NP789 and NP790. *US varieties*: Timstein derivatives, providing broad-spectrum resistance sources that were traced in the pedigrees of several NP varieties, including the multi-rust resistant NP809 (developed in 1954 after 18 years of research, resistant to all three rusts and loose smut).
These materials were selected for specific resistance traits: NP783 and NP784 for brown rust, NP785 and NP786 for yellow rust, NP789 and NP790 for black rust, and NP809 for combined resistance. The NP 700 and 800 series (e.g., NP700–NP800) similarly drew from these sources to target specific rust types, helping increase wheat production by reducing disease losses. This work laid the foundation for India's Green Revolution wheat breeding, with NP lines serving as parents in later varieties like Kalyan Sona.

Conclusion

We have discussed the conceptual framework of the Green Revolution. Besides the scientific idea at the heart of this revolution, we have also highlighted its primary goal. It was driven by ideology hidden under purely humanitarian goals seeking rapid food production to address hunger and poverty in developing countries. There was little novelty in the idea. It, in essence, copied the model of intensification of agriculture that emerged in the developed countries of Europe and America since the beginning of the 1940s. It was centered on growing a limited number of high-yielding crop varieties with application of substantial amounts of external inputs – chemical fertilizers, irrigation water, and chemical pesticides. Farmers had to purchase these inputs including high-yielding seeds. While in developed country agriculture with large landholdings and farm owners' ability to afford the use of substantial

quantities of external inputs, it was not a realistic option for poor and resource-limited smallholders in developing countries. Nevertheless, many national governments in Asia and Latin America were persuaded and supported by the US-led global financial mechanism and agricultural research support system to accept this model of agricultural intensification. We have discussed in detail the benefits and the costs of the Green Revolution.

The tragedy of the revolution lies in its overpromise versus irreversible damages that it inflicted on traditional agricultural systems, which were nature-based and not reliant on synthetic fertilizers and other chemical inputs. It also promoted inequality and stratification in rural societies. It was because the gains from the revolution were disproportionately appropriated by relatively large landholders and richer farmers who could afford buying external inputs for use in agricultural production. This view is corroborated by a CIA Report prepared in 1972 and declassified in 2006. An excerpt from the Report titled "India's Foodgrain Situation: Progress and Problems, Intelligence Memorandum, Central Intelligence Agency, August 1972" is shown below.



3. The so-called Green Revolution in India has generated a new se of problems, mainly related to the high wheat procurement price, whicl greatly increased government subsidy costs and induced farmers to shif irrigated land to wheat from other crops. The budgeted wheat subsidy fo the current fiscal year is more than four times as large as last year. Whea in some cases replaced commercial crops needed to maintain industria output, and in other cases replaced coarse grains and pulses, which are staple foods and major sources of protein for the poorer classes. Disparities ir rural income also have increased, as wealthier farmers with large holdings of irrigated land quickly adopted the HYV seeds and raised profits. Meanwhile, farmers without irrigation and with small holdings have generally been bypassed by the new technology.

However, genetics-driven improvement of yield potential, which was the promise of the Green Revolution, didn't last long. Since then the emphasis shifted on using ever increasing amounts of fertilizer, pesticides, and irrigation water.

The Green Revolution has ruined the most prized asset that nature has gifted to humanity for producing food: the soil, the mother of all resources needed to grow crop plants. Increase in the number of times crops are grown in the same land in a yearly cycle – intensification of cropping – caused progressive depletion of natural soil fertility. It was because uptake of plant nutrients from the soil by harvested crops over a long period exceeds replenishment by addition of chemical fertilizers. Increasing use of chemical inputs has also suppressed microbial soil health. Soil's ability to function as a living organism to make nutrients available to growing plants has been severely degraded. Intensive cropping has left little opportunity for farmers to leave the land fallow in order for the soil to restore its fertility through natural processes. In many countries, the situation with soil fertility is so dire that farmers have little option to continue growing crops other than using chemical fertilizers. This is how the Green Revolution has caused irreparable damage to smallholder farmers in developing countries. So, going back to the name, many still wonder what was the "revolutionary" in the phenomenon called "Green Revolution".